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Serial Casting as Conservative Management for Heel Cord Lengthening in the Pediatric Cerebral Palsy Population: A Case Report

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Abstract

Background: Ankle plantarflexion contractures are common among children with spastic cerebral palsy, resulting in a toe-walking gait pattern. While surgery for heel cord lengthening is common, many parents look towards a more conservative treatment method. The purpose of this case report is to highlight the successful use of serial casting for the treatment of an ankle plantarflexion contracture. **Case Description:** The patient was an 11-year-old female with spastic hemiplegic Cerebral Palsy and a right plantarflexion contracture. She could no longer wear her custom-fit ankle foot orthosis (AFO) and ambulated with a toe walking pattern on her right side. She previously was treated by physical therapy for aggressive manual stretching. **Intervention:** Four weeks of serial casting by a physical therapist was used in an attempt to reduce her ankle contracture and allow for a new AFO fitting. The serial casts allowed for weight bearing throughout daily activities. **Outcomes:** The patient gained 16° of passive dorsiflexion range of motion (PROM), and 9° of active range of motion (AROM). After casting, the patient was able to be fitted for a custom AFO and demonstrated heel strike more consistently in her gait pattern. While the patient demonstrated minimal muscle atrophy on her R ankle, she was given a home exercise program for strengthening following the intervention. **Discussion:** This case report describes the utilization of serial casting as a conservative treatment approach for heel cord lengthening with minimal complications, such as skin irritation. These results suggest that serial casting may be an option to help regain ankle range of motion and improved gait performance in children with cerebral palsy.

Background

One of the many impairments of Cerebral Palsy is difficulty with walking. Many individuals with Cerebral Palsy demonstrate increased muscle tone with exaggerated reflexes (spasticity), walking on toes, and a crouched gait among other neuromuscular abnormalities.[1] In individuals with spastic Cerebral Palsy, one component that has been correlated with toe walking includes fixed ankle equinus contractures as children grow and muscle deformities progress.[2] Previously, surgical heel cord lengthening was the treatment of choice for spastic ankle equinus contractures. This treatment includes a postoperative immobilization period (generally 3-4 weeks) and some rate of recurrence for ankle contractures (17-48%).[3] Other interventions for spasticity and pes equinus for Cerebral Palsy include static and prolonged muscle stretching, casts, ankle–foot orthoses (AFOs), and botulinum toxin type A (BTX-A).[4]

Repeated casting for foot deformities has been widely used for children with club feet since the 1950's. Ponseti utilized a weekly plaster casting protocol to conservatively and slowly correct club-foot deformities.[5] Shortly after in the 1960's, plaster casting began to be used in children with Cerebral Palsy to address abnormal reflex activity that was believed to be creating abnormal postures, including plantar-flexed ankle joints.[6] Since then, serial casting has turned into a treatment of choice for those with Cerebral Palsy and plantarflexion contractures.

Serial casting involves the application and removal of a series of casts with increasing range of motion (ROM) on each cast. These casts provide a low-load, long-duration force to the soft tissues creating a stretch and lengthening effect.[7] It is hypothesized and shown in animal models that incremental static stretch increases the number and length of sarcomeres in series, changing the muscle's length–tension relationship.[8] The physiological principles behind serial casting has not been well confirmed or supported in human subjects.[4]

Currently, serial casting for improving and maintaining ankle range of motion has been shown as an effective intervention for Cerebral Palsy, and shows improvements in the body structure/function and activity levels of the ICF model.[9] With casting becoming a favored intervention for contracture and equinus management, and even being called a standard of care for those with Cerebral Palsy, this intervention has been increasingly popular in today's world.[4,9] The purpose of this report is to describe the successful use of serial casting in an adolescent with spastic cerebral palsy and an ankle contracture, and to discuss positive and negative outcomes the patient and family observed.

Case Description

The selected patient was an 11-year-old female with spastic hemiplegic Cerebral Palsy affecting her right side. She demonstrated increased involvement in her right lower extremity compared to her upper extremity. Her right ankle had developed a plantarflexion contracture over some time, resulting in a toe walking gait pattern on her right side. She had previously worn a custom-fit ankle foot orthosis (AFO) on her right side to assist with impaired dorsiflexion strength. The patient and her mother reported that the AFO was no longer fitting correctly and was uncomfortable to wear due to her ankle contracture. Both stated their goal for treatment was to gain enough range to be fit for a new custom AFO and to decrease toe walking on her right side.

This patient had completed serial casting in the past (1 year prior) for a similar reason and wanted to trial a second bout of casting rather than undergoing surgical heel cord lengthening. Surgical procedures were not a favorable option at this time, as the patient has a comorbidity of Type 1 Diabetes which would lead to surgical and recovery complications. Prior to the intervention, the patient had undergone 2 months of an intense stretching protocol with physical therapy that was beneficial, but did not fully regain passive dorsiflexion ROM. Another previous intervention included injection of BTX-A, which was not tolerated well by the patient with reports of high pain and discomfort levels during and after injection.

This patient was an ideal candidate for serial casting and this case report, as her primary diagnoses consisted of spastic cerebral palsy and an ankle plantarflexion contracture. Other criteria

that matched included failure of other conservative treatments, such as manual stretching with physical therapy and poor tolerance of BTX-A. The patient had no signs of skin breakdown, no behavioral issues, and was independent in ambulation, all predisposing factors for successful serial casting.

Examination

Upon examination by a Physical Therapist, the patient demonstrated normal ROM through her left ankle and a impaired dorsiflexion ROM in her right ankle. PROM in her right ankle with the knee flexed was lacking 3 degrees to neutral, demonstrating ankle stiffness. With the knee extended, PROM was lacking 6 degrees to neutral, demonstrating tightness in the gastrocnemius and soleus muscles. A Modified Ashworth test was given, with no spasticity or increased tone in her left, unaffected ankle. The patient's right, affected ankle demonstrated increased muscle tone throughout full PROM with a catch and release of spasticity at -6 degrees (Modified Ashworth score of 1+).

With a barefoot observational gait analysis, the patient demonstrated minimal heel contact on her right side when walking. More consistently, she demonstrated a toe strike during initial contact with her right lower extremity. In combination, she demonstrated a lack of full knee extension during stance phase with intermittent vaulting on her right. During right swing phase, she demonstrated circumduction for toe clearance and increased knee flexion. Overall, a lack of neutral dorsiflexion ROM was correlated with gait abnormalities including unilateral toe walking, circumduction, and impaired initial contact on her right side when ambulating.

Intervention

The patient underwent 4 rounds of serial casting provided by a trained physical therapist, with the intervention lasting a total of 1 month. Each cast was applied in several layers, including cotton wrapping and a stockinette, cotton padding over bony prominences, plaster casting, and fiberglass casting (a similar process is pictured in Lee, et al. 2011.[17] Care was taken to provide excess padding over bony prominences and high friction areas to reduce risk of skin breakdown, as immobilization in a stretched state creates increased tension through soft tissue structures.

The patient's ankle was casted at an angle past the first point of resistance to produce a stretch through soft tissues, but at an angle that was still tolerable to the patient. The month schedule with casting angles and resistance points are shown in Table 1. The patient was instructed to continue weight bearing through the cast during normal activities after a 2 hour drying period. After 1 week, the patient returned and the cast was removed. Skin inspection was completed to monitor any skin breakdown, followed by cleaning and drying her lower leg to remove any fiberglass residue (common with cast removal). While our patient had no sign of skin breakdown, general protocol when a reddened area is found includes either increasing padding around irritated areas or to cease casting. Prior to casting for the next week, the patient walked barefoot for observational gait analysis and underwent PROM, AROM, tone and spasticity testing to monitor weekly changes.

Table 1. Casted angle and first point of resistance in passive range of motion for each weekly serial casting intervention.

Week	Casted Angle (°)	First Resistance Point (°)
1	-3	-6
2	1	0 (with clonus)
3	3	0 (no clonus)
4	4	1

Upon completion of casting, the patient and her mother were given a stretching and strengthening home protocol to assist in maintaining range of motion. Prior to discharge, both patient and her mother demonstrated these exercises to ensure proper stretching technique. The patient also

was fitted with a new custom-AFO for her right lower extremity by the in-house orthotist to increase ankle stability, assist in gait throughout school and daily activities, and also help maintain ROM.

One month after serial casting concluded, the patient returned to therapy for a follow-up appointment with the physical therapist and physiatrist to measure any changes in range of motion, tone, and spasticity, as well as an appointment with the orthotist to ensure continued proper fitting of her AFO. At this time she also received an updated home program to progress previously prescribed stretching and strengthening exercises.

Outcomes

After 4 weeks of serial casting, the patient demonstrated progress in both passive and active dorsiflexion ROM in her right ankle, listed in Table 2. With this increased joint range past a neutral position and increased gastrocnemius length, she was able to be fit for a new custom AFO by the in-house orthotist. Her custom-fit AFO included a slight heel lift shown in Figure 1 to accommodate for a ¾" leg length difference (determined by a prior CT scan) and increase tolerance of dorsiflexion assist, both of which were determined by the physiatrist and orthotist.

Table 2: Pre- and Post-Intervention measures demonstrating an increase in both passive range of motions, active range of motion, and angle of first resistance noted with passive stretch.

	PROM, Knee Flexed (°)	PROM, Knee Extended (°)	AROM, Knee Flexed (°)	Angle of First Resistance (°)
Pre-Intervention	-3	-6	-5 to -3	-6
Post-Intervention	12	10	2 to 3	2 to 3
1 Month Post	10	8	1 to 2	1 to 2

An observational analysis was completed after completion of casting and at the 1 month follow-up. In both appointments, the patient walked while barefoot and with her new custom-AFO. While walking barefoot, the patient demonstrated a flat foot initial contact, improved toe clearance with no circumduction, and weight bearing through the heel on her right foot during stance phase. With dorsiflexion assist of her custom-AFO, the patient demonstrated a heel strike during initial contact and no significant gait abnormalities. These gait observations were visible again at the 1 month check-up, demonstrating maintained gait quality improvements in the short-term period after casting.

Discussion

The purpose of this report was to describe the successful use of serial casting in an adolescent with spastic cerebral palsy and a unilateral ankle contracture, as well as to discuss positive and negative outcomes that the patient, mother, and physical therapist observed. The treatment was deemed successful, as goals of the family, physiatrist, and physical therapist were met. An outcome of increased passive and active ROM in the patient's right ankle allowed for completion of a new custom-AFO and return to normal gait mechanics as determined by the therapist and physiatrist (return to heel strike during initial contact and full foot weight bearing during stance phase).

Figure 1. The patient's custom AFO with a ¾" heel lift circled in red

Serial casting for the management of ankle contracture in pediatric Cerebral Palsy cases is on the rise and is beginning to be referred to as a "standard of care" for this population.[4,9] Currently, there is limited research comparing serial casting to surgical heel cord lengthening in individuals with Cerebral Palsy.[4] Some

research has been completed comparing these interventions for idiopathic toe walking in the pediatric population, demonstrating the preference of surgical heel cord lengthening.[10] This research cannot be translated to individuals with Cerebral Palsy due to the differences in pathophysiology underlying toe-walking in the two populations.[11]

When deciding on treatment for this patient's ankle contracture, many factors were considered. First, the most conservative treatment of stretching and physical therapy alone was trialed and failed to return enough PROM for proper fit of an AFO. Second, a surgical heel cord release was considered and not indicated at this time due to the patient's comorbidity of Type 1 Diabetes. Third, BTX-A injections were trialed in the past and were not tolerated well by the patient. In accordance with this, BTX-A with a combination of serial casting has inconclusive evidence of success with some literature noting earlier recurrence of spasticity, contracture, and foot equinus.[12,13] With all of these factors taken into consideration and previous success of the intervention with this patient, serial casting was determined to be the best treatment and course of action at the time.

Through the casting intervention, this patient demonstrated gains in dorsiflexion ROM past neutral in her affected ankle. This is similar to literature on serial casting, which report gains in PROM immediately following casting.[11,12,14,15] The patient in this case study demonstrated maintained PROM compared to baseline values at 4 weeks following casting, similar to previous available research.[12,15] It is difficult to predict how long the increased ROM effect of casting will last for this patient, as there is conflicting evidence available at this time. Kay, et al. reports maintained ROM up to 12 months following casting intervention. At the same time, McNee, et al. reports a return near baseline ROM by 12 weeks and Brouwer, et al. reports a similar return near baseline at 6 weeks.[12,14,15] In this case scenario, it is likely that our patient will eventually see a recurrence of an ankle contracture, as this is present in her past medical history.

One negative side effect of serial casting cited in literature is skin irritation and breakdown.[4] Some studies even report pressure sores occurring with casting due to poor protection of bony prominences.[13] The patient in this case study described mild irritation of the skin in the form of itching and dryness, which was expected with plaster casting procedures. Care was taken between each casting procedure to monitor any redness or painful areas to prevent further skin breakdown.

A negative side effect described in previous literature that our patient did not report includes increased weakness post-casting in the gastrocnemius and soleus musculature.[16] In comparison, surgical heel cord lengthening includes postoperative immobilization period (generally 3-4 weeks), which would result in similar weakness post-intervention.[3] In this case study, the patient and mother did not note any significant weakness following casting, contradictory to published literature. AROM from pre- to post-intervention improved in this case, which was likely due to decreases in ankle contracture and not strength considering the patient's diagnosis of spastic hemiplegic cerebral palsy.

Conclusion

In conclusion, the patient selected in this case demonstrates the successful use of serial casting as a conservative management for heel cord lengthening. Patient selection was key, as the patient tolerated the casting and removal process and was independent in all ambulation. Careful casting procedures ensured that known negative side effects, such as skin irritation/breakdown were minimized. While this patient demonstrated dorsiflexion ROM gains upon completion of casting and at a 1 month follow-up, there is a possibility of recurrence of ankle contractures on her hemiplegic side. Although this case report demonstrates how casting was successful while physical therapy and stretching alone were not, current research is limited on the physiology behind serial casting, the duration of ROM changes from casting, and comparison of serial casting compared to surgical heel core procedures. Therefore, this case report cannot be generalized to all children with cerebral palsy and an ankle contracture, but does show how serial casting was effective in an isolated situation.

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